Office of Technical Assistance Research Proposal

In-Situ Ozone Generation for Color Reduction

Abstract

The overall objective is to investigate a means of producing ozone in-situ from water for the purpose of oxidizing high concentrations of organic waste in industrial wastewater. The proposed research will lead to the production of an electrode that can be used to generate nascent oxygen from wastewater, combine the oxygen to form ozone and disperse the ozone to react with colorants and other organic waste in solution near the surface of the electrode. The electrode has to be robust, insensitive to a variety of impurities and must be available in a physical form with high surface area.

Background

There is a lot of interest in using ozone to replace the ubiquitous sodium hypochlorite as an oxidizing agent. Several attempts have been made for commercial applications of ozone to oxidize colorants in textile mills and as part of the bleaching sequence in pulp mills to oxidize colored lignin products. Ozone can also be used to remove or reduce colors from synthetic dyes. In the state of Massachusetts, there are many textile finishing and paper mills that discharge millions of gallons of colored wastewater to the local POTWs or to receiving waters every operating day. According to an EPA estimate, approximately 160 pounds of water (20 gallons) are required to produce 1 pound of textile product. In the state, information on OTA database indicates that there about 11 textile finishing plants, 12 companies producing coated fabrics and between 4 and 6 companies that dye their own yarns from cotton, wool and synthetic materials.

Between 1.3 and 3.3 gallons of water is required to produce 1 pound of paper, depending on the grade, quality and closure of the mill's white water system. From the same database, there are about 12 paper mills, 3 paper board mills, 13 companies using coated and laminated paper to produce packages, 7 companies producing corrugated solid fiber boxes, 1 company producing sanitary food containers and 1 producing folding paperboard boxes.

These companies need to change process water when they change the colors of their products. The wastewater generated is in millions of gallons every operating day. The volume will be drastically reduced if after decolorizing and simple treatment options, cleaner water from the wastewater streams can be recovered and recycled in to processes within the facilities. The wastewater may not be toxic by itself but the colors are for the most part aesthetically offensive and they detract from the recreational use of the receiving rivers and streams.

The USEPA is contemplating establishing color parameters for discharges to surface waters, which could place a burden on industrial dischargers with NPDES permits. Historically, the restrictions on discharges of non-toxic wastes to waste- treatment plants and/or directly to surface waters are limited to surcharges when predetermined limits are exceeded.

Ozone comes highly recommended as an oxidant. It decomposes quite readily to oxygen. It acts to eliminate bacteria in solutions. It can be used for odor control.
Some of the drawbacks in using this oxidant include the high cost of generation and the poor efficiencies in distributing, contacting and reactivity in aqueous solutions. A cost effective, non-toxic process for oxidizing organics would pave the way for the adoption of water recycling by water intensive processes such as paper and textiles.

Production and Application Methods
Ozone is produced mainly by corona discharge into a stream of oxygen or purified air flowing through a gap between two electrodes. The high voltage applied supplies energized electrons that collide with and break the otherwise stable oxygen bonds. In the process, some ozone molecules are formed and heat is generated. The concentration of ozone in the resulting gas streams depends on the concentration of oxygen in gas stream and the general purity of the gas stream. The concentration of ozone is usually below 10% and the generation process is not very efficient. When air is used as the raw material, some nitrogen oxide compounds (NO_x about 1%) can also be produced.
In the gas phase, ozone is quite unstable dissociating quickly into oxygen. Oxygen by itself is an oxidant but it is not as reactive as ozone.

Research Objective
The proposed research aims at finding cheaper methods to produce ozone and use it with minimum waste. One path is to produce it electrochemically and use it in-situ. The proposed research will lead to the production of an electrode that can be used to generate nascent oxygen from wastewater, combine the oxygen to form ozone and disperse the ozone to react with colorants in solution near the surface of the electrode. The electrode has to be robust, able to withstand fouling by a variety of impurities and it should be available in a physical form with high surface area for optimum contact for the ozone to react effectively. The system should include a provision for suitable venting or use of any hydrogen that is produced in the electrochemical reactions.

OTA can assist in the identification of an industry partner for this project.